

REMARKS

I. Status

No claims have been amended in this paper. There is no issue of new matter.

Upon entry of this paper, claims 85-88, 90, 93, 95-100, 104-116, 135-137, and 141-175 are pending and subject to examination.

II. Claim rejections - 35 U.S.C. § 112

In the Advisory Action, the Office maintains the rejection of claims 85-88, 90, 93, 95-100, 104-116, 135-137, and 141-175 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Office also maintains the rejection of claims 85-88, 90, 93, 95-100, 104-116, 135-137, and 141-175 are rejected under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the enablement requirement. See Advisory Action at page 2. Specifically, the Office contends that the Tgi is not a constant, and that the corresponding pages of the Polymer Handbook, supporting Tgi is a constant, "is not provided in the reply nor elsewhere in the record and was not considered." *Id.* Applicants respectfully disagree and traverse this rejection for the following reasons as well as for the reasons of record.

Applicants maintain that Tgi as used in the present claims is theoretical and is a constant for a given monomer. Applicants hereby submit copies of the corresponding pages of the Polymer Handbook showing that Tgi is a constant for each particular monomer. For example, the Tgi for acrylic acid is 379 K (which is approximately 105.84 °C (379 K - 273.16)). Applicants note that, as shown on the attached copy of page VI 197, there are more than 10,000 papers containing data regarding glass

transition temperature, the attached copies of the corresponding pages of Polymer Handbook only representing a fraction of those data.

As such, the claims are not indefinite as would have been recognized by one of ordinary skill in the art. Accordingly, Applicants respectfully request that the rejection be withdrawn.

CONCLUSION

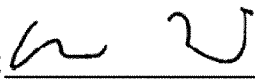
In view of the foregoing remarks, Applicants respectfully request reconsideration of this application, and the timely allowance of the pending claims.

Please grant any extensions of time required to enter this response and charge any additional required fees to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

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By: 
Wen Li
Reg. No. 62,185

Tel: (650) 849-6649

POLYMER HANDBOOK

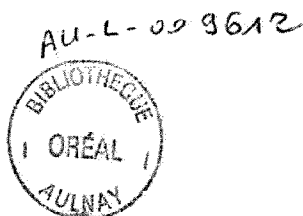
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J. BRANDRUP, E. H. IMMERGUT, and E. A. GRULKE

Associate Editors

A. ABE
D. R. BLOCH



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Glass Transition Temperatures of Polymers

Rodney J. Andrews, Eric A. Grulke

Chemical and Materials Engineering, University of Kentucky, Lexington, KY 40506-0046, USA

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Increased mobility

and moderate fractions of high molecular weight molecules (long chains that have more than one crystallite) provide physical evidence to increase T_g .

Some polymer families, such as the methacrylates and polystyrenes, show high dependencies of T_g on molecular weight. Intermolecular bonding can affect T_g either by increasing the cohesive energy of chain segments, or by restricting the backbone degrees of freedom of chain segments. The last concept has been used (1240) to aid in distribution models.

As molecular weight increases, polymer T_g 's may be little affected (51,52) (at least for isothermal crystallization (53)) or may decrease (51,54). T_g values reported in this work are the highest quoted on the sample for a given degree of crystallinity, other factors being equal.

In general, the presence of crosslinks in a sample increases T_g relative to an uncrosslinked sample. This effect can be independent of the chemical composition of the crosslinking agent, caused by the restricted motion of the segments near crosslinking sites. However, the crosslinking agent can behave similarly to a second monomer, inducing either an increase or a decrease in T_g as a copolymer effect.

Impurities

A variation in published T_g data is caused by the presence of impurities in the samples. Common impurities are unpolymerized monomer, low molecular weight polymer, solvents, etc. Great care should be taken to remove such impurities. Their presence in small concentrations can lead to a decrease in T_g of over 40°C and sometimes to the appearance of "diluent transitions", for example "water transitions". Reported values are from publications that describe steps taken to exclude diluents and the residual effects of these diluents. Few references contain this information and most values should be regarded as only approximate.

Molecular Weight

T_g of a homopolymer generally increases with increasing molecular weight up to a limiting value, known as the limiting or persistent T_g value (48,104,105). The limiting value holds for polymers with particular end-groups or where crystallinity decreases with increasing molecular weight (107). For some polymers, T_g 's are independent of molecular weight (108).

For condensation polymers, especially on low molecular weight and it seems likely that T_g values would be obtained if higher molecular weight samples were tested. Many polymers are not characterized with respect to molecular weight and the reported molecular weight distributions. In such cases, the only measure of molecular weight is a

value, which itself can be very dependent on polymer interactions and, to some extent on the temperature. Usually, the highest viscosities and the highest molecular weight polymers are associated with the most reliable data.

The classical model for the effect of molecular weight on T_g is (1219-1226)

$$T_g = T_g^\infty - \frac{A}{M_n}$$

This model suggests that the glass transition temperature reaches a limiting value when the number average molecular weight of the polymer is large. Cowie and Toporowski (1220) have shown that there is no further increase in T_g when the molecular weight is above a critical value, which is similar to the critical molecular weight for viscosity.

5. Thermal History

We have previously discussed in detail how thermal history (cooling rate, annealing time, and temperature), as well as the method of T_g measurement affects the reported T_g .

6. Pressure

Increasing pressure increases T_g in a linear relationship. A simple model is (Refs. 1227-1230)

$$T_g(p) = T_g(0) + sp$$

where $T_g(p)$ is the glass transition temperature as a function of pressure, p is pressure, and s is the linear pressure coefficient. This coefficient is 0.2 K/MPa for flexible aliphatic chains, and 0.55 K/MPa for semirigid aromatic chains (1231-1233). The effect of pressure on T_g can be important in some processing applications, such as injection molding. A different method for modeling the effect of temperature takes into account pVT data near T_g (1235-1237), giving an equation that includes the bulk modulus of the polymer glass.

D. ESTIMATION METHODS FOR THE GLASS TRANSITION TEMPERATURE

Several researchers have developed group contribution methods for correlating polymer properties, including the glass transition temperature (1238-1240). These techniques emphasize quantitative modeling of the various effects of polymer structure on T_g , and are a valuable aid to interpreting experimental data and estimating glass transition temperatures for new materials.

E. CLASSIFICATION, NOMENCLATURE, AND ABBREVIATIONS

Over 10000 papers contain glass transition data (43). This section of *Polymer Handbook* represents a fraction of these

data. Most of the data in the tables are for linear homopolymers. In general, the polymers contain no additives or diluents, and are thought to have low or no branching.

Polymers are subdivided into principle classes by the composition of their repeating chain segment: acyclic carbon polymers, carbocyclic polymers, acyclic heteroatom polymers, heterocyclic polymers, and copolymers. All entries are placed in the most senior class their structure commands (109,110) and appear in only one class. The subclasses and their entries are organized in alphabetical order.

1. Naming Conventions

With the exception of common polymers with accepted trivial names, the polymers are named substantially according to the ACS recommendations for polymer nomenclature (110) in conjunction with IUPAC rules (109); less common polymers are cross-referenced from the trivial to the systematic name. Systematic names are not given for all the polymers in order to save space. Substitutive nomenclature is generally used for simple radicals, but for long combinations of radicals replacement nomenclature has been used to provide a much shorter name (as for some fluorocrylates with ether side chains).

When sequences of radicals have repeated, the repeating sequence has been written once and prefixed "di", "tri", etc. as appropriate, for example, di(oxyethylene) for the sequence $-O-CH_2-CH_2-O-CH_2-CH_2-$. Note that the diradical "di(oxyethylene)" must be distinguished from the diradical "dioxyethylene" which has the structure, $-O-O-CH_2-CH_2-$, and also the diradical "ethylenedioxy" which has the structure, $-O-CH_2-CH_2-O-$ (IUPAC rule C205.2). The principle underlying the last-named diradical has not generally been extended to the naming of polymers in this section, i.e., diradicals of structure $-X-Y-X-$ are not named YdiX, with the exception of alkanedioyl diradicals, because of the difficulty of locating indexed polymer names in which the diradicals are not named from left to right. Many polymers are derivatives of the diradical "propylene" $-CH(CH_3)-CH_2-$; the substituted diradical

"propylene" is used in naming polymers instead of "methylethylene" which could be preferred.

Polymer names are tabulated in alphabetical order in each subsection, but

1. prefixes like *sec*-, *tert*-, including designations and the numbers showing locations of substituents, are ignored except as secondary and tertiary indicators in alphabetical order. For example, poly(ethylene 2,6-naphthoate) appears before poly(ethylene 1,4-terephthalate), and poly(4-*p*-anisoylstyrene) appears before poly(4-*o*-anisoylstyrene).
2. multiplying prefixes for various substituents, such as dimethyl or trimethyl, are observed in alphabetical order rather than being grouped together at the end of the 3rd edition of this Handbook.
3. the locations of substituents in otherwise identical polymers are taken as tertiary indicators of order. Numbers are arranged in increasing order at the point of difference. Thus, 2,3,8- comes before 2,3,9-.

Comments may include information as to the instrument used for measurement and, whenever possible, information concerning the method of DSC measurement (e.g., whether the conditions of measurement, thermal history, and whether measurements were made as a function of a particular variable such as molecular weight ($f(MW)$)).

2. Abbreviations

HR	Heating rate
CR	Cooling rate
OCR	Zero cooling rate
Xp	Extrapolate
TH	Thermal history
DSC	Differential scanning calorimetry
TMA	Thermal mechanical analysis
DTA	Differential thermal analysis
DMA	Dynamic mechanical analysis
MW	Molecular weight
$f(\)$	Function of a variable
Mdpt	Midpoint
Intg	Integration

F. TABLES OF GLASS TRANSITION TEMPERATURES OF POLYMERS

TABLE 1. MAIN-CHAIN ACYCLIC CARBON POLYMERS

Polymer	CAS No.	T_g (K)	Remarks
1.1. POLY(ACRYLICS) AND POLY(METHACRYLICS)			
1.1.1. POLY(ACRYLIC ACID) AND POLY(ACRYLIC ACID ESTERS)			
Poly(acrylic acid)	9003-01-4	379 348	
Poly(1-adamantyl acrylate)		426	
Poly(adamantyl crotonate)		507	
Poly(adamantyl sorbate)		388	
Poly(benzyl acrylate)		279	

TABLE 1. *cont'd*

Polymer	CAS No.	T_g (K)	Remarks	Ref.
Poly(2-ethylbutyl acrylate)		223	Brittle point	
→ Poly(2-ethylhexyl acrylate)	9003-77-4	223	Brittle point	
Poly(ferrocenylethyl acrylate)		430	No experimental details	
Poly(ferrocenylmethyl acrylate)		470-483	DSC heating rate	
Poly(3-fluoroalkyl α -fluoroacrylate)		398		
Poly(4-fluoroalkyl α -fluoroacrylate)		368		
Poly(5-fluoroalkyl α -fluoroacrylate)		374		
Poly(8-fluoroalkyl α -fluoroacrylate)		338		
Poly(17-fluoroalkyl α -fluoroacrylate)		388		
Poly(fluoromethyl acrylate)		288	Estimated T_g	
Poly(furfuryl acrylate)		321		
Poly(1H, 1H-heptafluorobutyl acrylate)		243		155,86
Poly(5,5,6,6,7,7,7-heptafluoro-3-oxaheptyl acrylate)		228		
Poly(2,2,3,3,5,5,5-heptafluoro-4-oxapentyl acrylate)		218		830
Poly(heptafluoro-2-propyl acrylate)		278-283	No details on sample or measurement	
Poly(heptyl acrylate)		213	Brittle point	821,34
Poly(2-heptyl acrylate)		235	Brittle point	
Poly(hexadecyl acrylate)		308	Brittle point	23,821,84
Poly(1H,1H,3H-hexafluorobutyl acrylate)		251		
Poly(hexyl acrylate)		216	Brittle point	
Poly(3-hydroxyalkanoate)		293		
→ Poly(isobornyl acrylate) conventional		367		
syndiotactic		369		
isotactic		362		
→ Poly(isobutyl acrylate)		249	Brittle point	
		230		
Poly(isopropyl acrylate) conventional		267-270		746,82
syndiotactic		271-284		
isotactic		262		
Poly(magnesium acrylate)		673	Estimated from copolymer data	
Poly(3-methoxybutyl acrylate)		217		
Poly(2-methoxycarbonylphenyl acrylate)		319		
Poly(3-methoxycarbonylphenyl acrylate)		311		
Poly(4-methoxycarbonylphenyl acrylate)		340		
Poly(2-methoxyethyl acrylate)		223		
Poly(4-methoxyphenyl acrylate)		324		
Poly(3-methoxypropyl acrylate)		198		
Poly(methyl acrylate) conventional	9003-21-8	283		18,22,3
		284	Dilatometer	
		290		
		282		1401,14
head to tail		278		576,720,775
head to head		304		821,824,831
				845
Poly(2-methylbutyl acrylate)		241	Brittle point	823
Poly(3-methylbutyl acrylate)		228	Brittle point	
Poly(2-methyl-7-ethyl-4-undecyl acrylate)		253	Brittle point	
Poly(2-methylpentyl acrylate)		235	Brittle point	
Poly(2-naphthyl acrylate)		358		
Poly(neopentyl acrylate)		295		746
Poly(1H,1H-nonafluoro-4-oxahexyl acrylate)		224		
Poly(1H,1H-nonafluoropentyl acrylate)		236		
Poly(nonyl acrylate)		215	Brittle point	
		184		
Poly(octyl acrylate)	25266-13-1	208	Brittle point	821,841
Poly(2-octyl acrylate)		228	Brittle point	
Poly(1H,1H,5H-octafluoropentyl acrylate)		238		
Poly(pentabromobenzyl acrylate)		453		
Poly(pentachlorophenyl acrylate)		420		
Poly(1H,1H-pentadecafluorooctyl acrylate)		256	Crystalline	
Poly(1H,1H-pentafluoropropyl acrylate)		247		
Poly(<i>n</i> -pentyl acrylate)		216		

	CAS No.	T _g (K)	Remarks	Refs.
		331		1359
		330		1360
		344		1413
		359	with 25% wt. of chromophore I-doped polymer	1418
		378	with 25% wt. of chromophore II-doped polymer	1418
		348		1438
		347	DSC	1484
		285		824
		339		847
		298		746
		482	No experimental details	834
		~458-468	DSC heating rate	835
		355		1263
		353		1263
		350		1263
		320		1263
		310		1263
		347		1269
		336		1360
		~330		875
		258	Mechanical method	876
	25986-80-5	288	Brittle point, sample probably crystalline-may be T _m	821,866
	25087-17-6	268		695,846, 858,877, 1251,1443
		273		1401
			DSC	1484
		270		1416
		274		1413
	25249-16-5	328, 359	Conflicting data	746,878-880
		311	DSC, dry Xp	1098
		393	DSC, dry Xp	1199
		349		846,878
		358		1279
		396/464/743		1401
	64114-51-8	383		824
		423		1508
		326		746,821,824
		281		846,881
		326		
	9011-15-8	326		1401
		337		1438
		354		746,824,862
	26655-94-7	358		1401
		300		
		358		
		335	Heating rate: 20 K/min	842
		~763	Xp value	843
	54193-36-1	501	Xp data from plasticized samples	882
		379		746
	9003-21-8	273		1255
	9011-14-7			1102,1112,1101, 1107,1108
			DSC, onset, 16 deg/min HR, quenched, f(MW)	1101
			Dilatometer, CR 3 deg/h; creep relaxation, quenched	1109
		378		1432,1315, 1401,1288,1318